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Enhancing Sleep and Reducing Occupational Stress Through Forest Therapy: A Comparative Study Across Job Groups

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Objective The coronavirus disease-2019 (COVID-19) pandemic radically shifted occupational patterns, leading to increased telecommuting and related stressors. Healthcare providers, among the most impacted group, faced heightened risks and workplace changes. Our study examined the efficacy of forest therapy in alleviating work-induced stress across various professions, exploring the need for profession-specific stress-relief strategies in the post-pandemic workplace.

Methods To examine the impact of COVID-19 on professionals, 62 participants were recruited, consisting of 20 healthcare providers, 21 information technology (IT) specialists, and 21 teachers. Instruments such as Pittsburgh Sleep Quality Index and Hospital Anxiety and Depression Scale, along with salivary tests for cortisol and melatonin, were used to assess the participants' sleep and stress levels. A specialized forest healing program was implemented among these participants. Data analysis was conducted using SPSS Win Ver. 22.0, utilizing paired t-tests and a repeated measures analysis of variance.

Results Significant improvements were observed in the participants' sleep metrics, depression scales, and stress levels after the forest healing program. Physiological measures indicated an increase in melatonin and a decline in cortisol and dehydroepiandrosterone sulfate levels, with only cortisol changes being statistically significant. Teachers, participating during school vacations, exhibited minimal stress-related physiological changes. Overall, the program demonstrated widespread health benefits regardless of occupation or gender.

Conclusion This study showed that forest therapy reduced stress equally across professions, including healthcare providers, IT specialists, and teachers. Individual physiological responses may play a greater role in stress relief than the specific occupation.

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Keywords Forest healing programs; Sleep quality; Occupational stress; Work–life balance.

INTRODUCTION

The coronavirus disease-2019 (COVID-19) pandemic precipitated a drastic shift in work dynamics across numerous working fields. In most occupations, workers were encouraged or required to telecommute wherever possible.[1] This sudden transition emerged as a significant stressor for many people.[2] Some employees reported that in order to adjust to the new work arrangements, they required more thorough training or had to come up with new methods of working. Some also asserted that they felt the usual amount of stress that accompanies any job change. However, many employees find it more difficult to maintain a work–life balance when they work from home, which leads to increased stress.[3] While some employees adapted swiftly to these changes and were satisfied by the new work format,[4] most were required to invest considerable time and energy adjusting to their new work environments. Given the unpredictable nature of global pandemics, future outbreaks may present different challenges. In order to manage the work-related stress of employees in the face of novel and unexpected pandemics, we need to have a strategy in place.

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By far the most stressful high-risk occupational group during the pandemic was healthcare providers.[5] A study from Taiwan revealed that hospital employees experienced significant stress because of their potential exposure to COVID-19 and the associated fear of both contracting the virus and causing subsequent infections, especially as their work settings underwent major changes during the pandemic.[6,7] Even four years post-pandemic, healthcare providers remain vulnerable to such stress. The continued threat of COVID-19 and the global persistence of mask usage in many hospitals to protect both staff and patients are contributing factors.

Many healthcare providers believe they need alternative methods to manage work-related stress,[8] which should be considered a social issue. Various stress management strategies have been proposed.[9,10] In particular, healing with natural resources is considered important in stress management and mental health treatment. Therapeutic interventions like forest, gardening, and marine therapy are based on natural elements.[11,12] Quantitatively and qualitatively, the Korean environment is abundant with forest resources. Therefore, forest therapy has been in development for a long time, and many programs are currently available. Additionally, its efficacy has been objectively verified by many studies.[13-16] Following the COVID-19 pandemic, we developed a forest healing program to reduce stress among hospital workers in challenging circumstances. Our results showed that the forest healing program alleviated the workers' stress.[17]

Based on a review of research on post-COVID-19 workplace adjustments, not only healthcare facilities but also other professions have been faced with new and challenging work environments.[2,18] Through this investigation, we endeavored not only to validate the therapeutic potential of forest environments for enhancing sleep and reducing occupational stress in the post-pandemic era but also to contribute to the broader discourse on sustainable, nature-based solutions for promoting mental health and well-being in our increasingly digital and remote work settings.

METHODS

Participants

Based on a review of the existing literature, we conducted a study focusing on three occupational groups that experienced increased work intensity or changes in the form of work due to the COVID-19 pandemic: healthcare providers, information technology (IT) specialists, and teachers. We recruited 20 or 21 participants in each group, including only those with at least five years of experience in their respective fields and excluding those with physical or mental impairments. The forest healing program ran from April to September 2022. This selection criterion was chosen to better reflect stress levels associated with work changes.

Variables

Four questionnaires were used to assess sleep quality. The Pittsburgh Sleep Quality Index (PSQI) includes questions about sleep quality, sleep duration, habits, sleep disorders, sleep medications, and daytime functioning. The scores for the seven domains are summed to give a total score ranging from 0 to 21. A score of 5 or higher indicates poor sleep quality. The Insomnia Severity Index (ISI) consists of seven sleep disturbance items, and a total score of 10 or higher indicates sleep disturbance. The Epworth Sleepiness Scale (ESS) measures fatigue, with a score of 11 or higher indicating excessive sleepiness. The Stanford Sleepiness Scale (SSS) is a seven-item tool that assesses one's immediate level of sleepiness.

In addition, seven questionnaires were used to measure stress. The Hospital Anxiety Depression Scale (HADS) has an eight-point cutoff for both depression and anxiety. The Depression Anxiety Stress Scale-21 (DASS-21) consists of depression, anxiety, and stress subscales, each of which contains seven items for a total of 21 items, with higher scores indicating higher levels of depression, anxiety, and stress. The Patient Health Questionnaire-9 (PHQ-9) was developed to assess changes in quality of life due to psychological symptoms like depression and anxiety. The Symptom Checklist-90-R (SCL-90-R) measures somatization symptoms. It includes subjective questions about circulatory, pulmonary, and other organ disorders as well as bodily dysfunctions, such as headaches and pain. The Perceived Stress Scale (PSS) consists of two domains with a total of 10 items: six negative stress perceptions and four positive stress perceptions. It provides a subjective assessment of the stress experienced over the past month, with higher scores indicating higher levels of stress. The Korean Resilience Quotient-53 is determined by the sum of all scores. Scores above 200 are considered reassuring, while individuals with scores below 180 are considered to be easily affected by even minor negative events. The Health Promoting Behaviors scale consists of 52 items covering health responsibility, exercise, nutrition, spiritual growth, relationships, and stress management. Each item is rated on a four-point scale to produce an average score, with higher scores indicating higher levels of health promoting behaviors.

Assessing physiological changes

In order to gather objective data regarding the degree of stress and sleep quality, a total of four saliva tests were conducted every day, both prior to and during the forest healing program. Saliva samples were collected upon awakening in the morning to conduct the cortisol test. Similarly, saliva samples

were collected shortly prior to bedtime to measure melatonin levels. The sampling time was 8:00 a.m., following the individual's awakening in the morning, whereas the collection of sleep-related data took place at 9:00 p.m.

The present investigation was carried out in accordance with the principles outlined in the Declaration of Helsinki. The research protocols employed in this study were approved by the relevant ethics review board, identified as #IS22OISE0013. Prior to engaging in the study, all individuals provided their informed consent.

The development of the forest healing program

We developed the final forest healing program based on the literature reviews, including the healing goal, expected healing factors, healing therapy items, and approach methods. The forest healing program consists of three parts: meeting the forest, meeting myself, and awakening myself.

The first part, meeting the forest, includes three activities. First, barefoot walking on forest paths enhances the five senses, allowing participants to connect deeply with natural elements like sunlight and sounds. This activity promotes relaxation and harmony with nature. Water/thermal healing follows, where feet heated from walking are cooled with water then treated with a dry foot bath for fatigue recovery and improved circulation. Conversation over tea involves activities centered around the enjoyment of the color, smell, and taste of tea. While drinking tea, participants engage in conversations in a comfortable atmosphere, focusing on these sensory experiences.

The second part, meeting myself, includes two activities. Aroma hand massage is a healing activity that promotes mental and physical stability through listening to calming music, such as white noise, while receiving a hand massage using aroma oil. Forest sound meditation is a healing activity conducted outdoors, where participants listen to various forest sounds, such as water, wind, and birds. During this activity, individuals focus on emptying their minds and reflecting on themselves.

The third part, awakening myself, includes three activities. Forest exercise is a healing activity that concentrates on the body, aiming to release tension from the head to the toes through exercises and deep breathing, thereby relaxing both mind and body. This includes bodyweight exercises, stretching with a yoga ring, and a combination of deep breathing and singing bowl meditation. The forest walk is a healing activity that involves walking leisurely along the forest path with a relaxed mind, providing rest to the heart. Finally, forest conversation is a healing activity in the forest where participants enjoy tea and comfortably share their feelings, thoughts, and impressions experienced through the program. Table 1 summarizes the program.

Statistics

The collected data were analyzed using the SPSS Win Ver. 22.0 program (IBM Corp., Armonk, NY, USA). The general characteristics of the subjects were analyzed using descriptive statistics, including frequencies, percentages, means, and standard deviations. A paired t-test was used for pre–post analysis, and a repeated measures analysis of variance was used to analyze pre–post differences between groups.

RESULTS

General characteristics

Table 2 presents the general characteristics of the study subjects. A total of 62 individuals participated, consisting of 20 healthcare providers, 21 IT specialists, and 21 teachers. The average age of the participants was 42.61±11.64 years, with 13 males and 49 females, representing a female ratio of 79%. The average height and weight of the participants was 167.90±42.54 cm and 62.54±12.45 kg, respectively. The average working period was 158.7±131.5 months.

Changes in mental and physical health status based on the questionnaire test

Table 3 presents the outcomes of the sleep-related indicators following the forest healing program. Except for SSS, all indicators demonstrated statistically significant differences. Notably, both ISI and ESS exhibited significant improvements after the program. Moreover, the HADS_depression, DASS-21, and PHQ-9 instruments revealed statistically significant positive changes after the program. In addition, significant improvements were noted in SCL-90-R scores and subjective stress levels following the program, as measured by the PSS. Statistically significant increases were also observed in resilience levels and health promotion activities. In summary, all the data presented in Table 3 demonstrated a statistically significant amount of improvement. The SSS shows the present degree of somnolence, suggesting a lack of significant change.

Changes in physiological variables after the forest healing program

Table 4 highlights the changes in cortisol, melatonin, and DHEA-S levels based on saliva tests conducted both pre- and post-intervention. Due to insufficient saliva volume, three samples were excluded from the analysis, leading to a final count of 61 cortisol, 58 melatonin, and 56 DHEA-S samples. The post-intervention results showed an increase in melatonin levels, while both cortisol and DHEA-S levels decreased. Among the physiological parameters, only the change in cortisol was statistically significant.

Table 1. Forest healing program

Program	Detailed activities	Healing goal	Healing factor	Healing therapy	Approach
Meeting the forest	Walking correctly on forest paths (barefoot walking)	Maintaining health in the forest	Oxygen Scenery Phytoncide Negative ions Sound Sunlight	Phytotherapy Climatotherapy Exercise therapy	Action-oriented
	Water/thermal healing	Maintaining health in the forest	Scenery Sound Negative ions	Hydrotherapy Psychotherapy	Emotion-oriented
	Conversation over tea	Sharing feelings	Scenery	Dietary therapy Psychotherapy	Acceptance-oriented
Meeting myself	Aroma hand massage	Looking back at myself	Sound	Psychotherapy Exercise therapy	Acceptance-oriented
	Forest sound meditation	Looking back at myself	Negative ions Sound	Psychotherapy	Acceptance-oriented
Awakening myself	Forest exercise	Maintaining health in the forest	Oxygen Scenery Phytoncide Negative ions Sound Sunlight	Phytotherapy Climatotherapy Exercise therapy	Action-oriented
	Forest walk	Looking back at myself	Scenery Phytoncide Negative ions Sound Sunlight	Phytotherapy Exercise therapy	Emotion-oriented
	Forest conversation	Sharing feelings	Oxygen Scenery Phytoncide Negative ions Sound Sunlight	Dietary therapy Climatotherapy Psychotherapy	Acceptance-oriented

The differences in program effectiveness across occupations

Table 5 shows the outcomes of the analysis comparing metrics across teachers, healthcare providers, and IT specialists pre- and post-intervention. Only cortisol, a stress indicator, showed significant differences among occupations. Teachers participated in the study during school vacations, undergoing the forest healing program when the typical school year stresses were likely reduced. There were minimal physiological changes in teachers before and after the program. A follow-up study separating the school year from the vacation period is needed to analyze the stress-reduction effect in this group. These findings suggest that the effects before and after the forest healing program are consistent across occupational groups.

The gender differences in program effectiveness

Table 6 shows the results of the analysis comparing the variance by gender pre- and post-intervention. Female scored statistically significantly higher than male on the SCL-90-R, a measure of stress somatization, both before and after participating in the forest healing program.

Table 2. General characteristics (N=62)

	Value
Sex	
Female	49 (79)
Male	13 (21)
Age (year)	42.61±11.64
Height (cm)	167.90±42.54
Weight (kg)	62.54±12.45
Working period (month)	158.7±131.5

Data are presented as mean±standard deviation or number (%)

Table 3. Changes in mental and physical health status based on the questionnaire test

Test	Pre	Post	t	p
PSQI	6.69±2.89	6.11±3.02	2.349	<0.001
ISI	9.48±4.05	9.45±3.81	0.074	<0.001
SSS	2.37±0.87	2.06±0.72	2.410	0.083
ESS	5.73±4.49	5.26±4.40	1.099	<0.001
HADS_anxiety	6.23±3.82	9.69±6.56	1.867	<0.001
HADS_depression	5.32±3.26	4.73±2.93	1.740	<0.001
DASS-21	8.29±9.34	6.16±7.14	2.203	<0.001
PHQ-9	3.85±4.01	2.53±2.85	2.873	<0.001
SCL-90-R	7.63±6.96	6.30±6.04	1.925	<0.001
PSS	25.61±7.24	24.18±7.20	1.850	<0.001
KRQ-53	154.27±23.22	156.01±21.15	-0.592	<0.001
HPB	83.03±15.10	85.50±15.85	-1.540	<0.001

Data are presented as mean±standard deviation. PSQI, Pittsburgh Sleep Quality Index; ISI, Insomnia Severity Index; SSS, Stanford Sleepiness Scale; ESS, Epworth Sleepiness Scale; HADS, Hospital Anxiety Depression Scale; DASS-21, Depression, Anxiety, Stress Scales-21; PHQ-9, Patient Health Questionnaire-9; SCL-90-R, Symptom Checklist-90-R; PSS, Perceived Stress Scale; KRQ-53, Korean Resilience Quotient-53; HPB, Health-Promoting Behavior

DISCUSSION

In the wake of the COVID-19 pandemic, the landscape of work environments underwent a significant transformation, leading to an increase in remote work and associated occupational stress.[19,20] This situation underscored the critical need for innovative strategies to manage stress effectively. Forest healing programs, recognized for their holistic benefits, have emerged as a promising approach in this context. This study revisits the role of forest therapy, not merely as a tool for stress reduction but also as a vital intervention for improving sleep quality among professionals navigating the pandemic-induced changes in work patterns.[17,21]

Forest environments, inherently capable of engaging all five human senses, provide a distinctive therapeutic setting to enhance mental and physical health.[22] Our research specifically targets the efficacy of forest therapy in boosting sleep quality—a fundamental yet frequently neglected component of well-being with profound implications for occupational stress management. Leveraging prior research that underscored forest therapy's broad benefits for diverse groups, including cancer patients and high-stress job holders,[17,23,24] our investigation broadens to assess its impact on sleep enhancements across varied professional demographics, such as healthcare workers, IT specialists, and educators.

Table 4. Changes in physiological variables after the forest healing program

Variables	Pre	Post	t	p
Cortisol	0.46±0.28	0.38±0.25	1.909	0.039*
Melatonin	20.15±12.76	73.79±54.04	-0.735	0.980
DHEA-S	11.65±43.79	7.48±11.99	0.651	0.724

Data are presented as mean±standard deviation. *p<0.05. DHEA-S, dehydroepiandrosterone sulfate

The compounded stress experienced by healthcare professionals due to their pivotal roles during the pandemic, alongside the challenges faced by IT specialists and teachers adjusting to new work modalities, prompted the deployment of an extensive forest healing program. This program was meticulously curated to optimize sensory interaction with nature, intending to cultivate profound relaxation and mental clarity conducive to enhanced sleep quality.

To gauge the forest therapy program's success, we assessed participants' sleep quality using the PSQI and physiological markers like cortisol and melatonin levels, alongside stress evaluations. This comprehensive approach enabled an in-depth understanding of the relationship between sleep improvement and stress mitigation.

Our findings demonstrate notable enhancements in sleep quality among participants, accompanied by reductions in stress and anxiety. These results affirm forest therapy's efficacy as an intervention for sleep improvement and, by extension, its role in alleviating occupational stress. Remarkably, the benefits of forest therapy manifested uniformly across all examined professional groups, illustrating its broad applicability irrespective of specific occupational challenges.

This study significantly contributes to the existing literature by supporting the therapeutic potential of nature-based interventions in enhancing sleep quality and managing workplace stress.[17,25] It underscores the importance of integrating natural environments into comprehensive health strategies, especially in addressing work dynamic shifts caused by global health emergencies.

The concept of "work–life balance" has gained prominence, emphasizing the necessity for individuals to effectively navigate their professional and personal lives.[26] The COVID-19

Table 5. The differences in program effectiveness across occupations

Variables	Occupations	Pre	Post	F	p
Cortisol	Teachers	0.53±0.27	0.49±0.34	3.21	0.05*
	Healthcare providers	0.41±0.21	0.37±0.19		
	IT specialists	0.43±0.36	0.27±0.16		
Melatonin	Teachers	52,555.14±217,062.31	210,037.31±919,829.34	1.43	0.25
	Healthcare providers	3,547.60±6,986.36	2,585.11±5,332.68		
	IT specialists	2,601.56±4,738.48	1,517.41±2,470.89		
DHEA-S	Teachers	21,430.98±76,637.19	3,688.93±7,074.24	0.24	0.79
	Healthcare providers	6,664.39±7,677.59	7,985.75±11,599.11		
	IT specialists	7,415.61±10,801.86	11,545.64±15,235.09		
PSQI	Teachers	6.76±3.25	6.33±3.50	0.96	0.39
	Healthcare providers	7.52±3.06	6.29±2.83		
	IT specialists	5.75±2.05	5.70±2.77		
ISI	Teachers	9.19±3.97	8.57±3.63	0.56	0.57
	Healthcare providers	9.95±4.31	10.14±3.07		
	IT specialists	9.30±4.01	9.65±4.64		
SSS	Teachers	2.48±0.98	1.95±0.59	0.00	>0.99
	Healthcare providers	2.43±0.75	2.00±0.55		
	IT specialists	2.20±0.89	2.25±0.97		
ESS	Teachers	5.86±4.44	5.33±4.50	0.51	0.60
	Healthcare providers	7.00±5.19	5.14±4.25		
	IT specialists	4.25±3.40	5.30±4.67		
HADS_anxiety	Teachers	5.57±3.93	4.95±3.35	0.53	0.59
	Healthcare providers	7.29±3.91	5.14±2.99		
	IT specialists	5.80±3.55	6.20±3.52		
HADS_depression	Teachers	4.62±3.19	3.90±2.90	1.23	0.30
	Healthcare providers	6.24±3.92	4.38±2.56		
	IT specialists	5.10±2.38	5.95±3.07		
DASS-21	Teachers	6.38±7.20	4.86±6.03	0.86	0.43
	Healthcare providers	11.00±12.19	6.19±5.61		
	IT specialists	7.45±7.51	7.50±9.41		
PHQ-9	Teachers	3.10±3.79	1.95±2.36	1.24	0.30
	Healthcare providers	5.57±4.71	2.33±2.13		
	IT specialists	2.85±2.87	3.35±3.79		
SCL-90-R	Teachers	7.33±7.10	5.05±4.71	1.13	0.33
	Healthcare providers	10.14±6.74	6.95±4.87		
	IT specialists	5.30±6.48	6.95±8.13		
PSS	Teachers	24.29±8.26	23.48±7.71	0.39	0.68
	Healthcare providers	26.71±5.65	23.81±6.96		
	IT specialists	25.85±7.73	25.30±7.12		
KRQ-53	Teachers	151.86±30.28	156.71±30.53	0.87	0.42
	Healthcare providers	159.14±9.96	159.52±12.11		
	IT specialists	151.70±24.97	151.60±16.30		
HPB	Teachers	84.38±20.27	91.10±20.45	1.61	0.21
	Healthcare providers	81.90±10.98	87.86±9.72		
	IT specialists	82.80±12.99	77.15±12.36		

Data are presented as mean±standard deviation. *p<0.05. DHEA-S, dehydroepiandrosterone sulfate; PSQI, Pittsburgh Sleep Quality Index; ISI, Insomnia Severity Index; SSS, Stanford Sleepiness Scale; ESS, Epworth Sleepiness Scale; HADS, Hospital Anxiety Depression Scale; DASS-21, Depression, Anxiety, Stress Scales-21; PHQ-9, Patient Health Questionnaire-9; SCL-90-R, Symptom Checklist-90-R; PSS, Perceived Stress Scale; KRQ-53, Korean Resilience Quotient-53; HPB, Health-Promoting Behavior

Table 6. The gender differences in program effectiveness

Variables	Sex	Pre	Post	F	p
Cortisol	Male	0.40±0.25	0.24±0.16	3.36	0.07
	Female	0.17±0.29	0.42±0.26		
Melatonin	Male	5,005.82±6,213.40	2,474.69±4,106.97	0.29	0.59
	Female	23,308.85±140,322.71	88,646.14±593,965.46		
DHEA-S	Male	3,546.19±4,902.86	4,866.61±7,832.24	0.78	0.38
	Female	13,633.74±48,699.20	8,453.44±12,776.92		
PSQI	Male	5.62±3.15	5.46±4.24	1.59	0.21
	Female	6.98±2.79	6.29±2.64		
ISI	Male	8.46±4.41	8.08±5.45	1.91	0.17
	Female	9.76±3.95	9.82±3.23		
SSS	Male	2.15±0.80	1.85±0.99	2.03	0.16
	Female	2.43±0.89	2.12±0.63		
ESS	Male	4.69±3.50	3.85±3.41	1.46	0.23
	Female	6.00±4.71	5.63±4.58		
HADS_anxiety	Male	5.62±3.01	5.31±3.59	0.21	0.64
	Female	6.39±4.02	5.45±3.23		
HADS_depression	Male	4.62±2.43	4.69±3.90	0.29	0.59
	Female	5.51±3.44	4.73±2.67		
DASS-21	Male	6.08±7.61	4.85±8.17	0.94	0.38
	Female	8.88±9.74	6.51±6.89		
PHQ-9	Male	2.54±3.50	2.62±3.91	0.71	0.40
	Female	4.20±4.10	2.51±2.55		
SCL-90-R	Male	4.00±4.18	2.46±2.88	7.19	0.01*
	Female	8.59±7.26	7.33±6.26		
PSS	Male	22.77±9.44	21.23±9.38	3.34	0.72
	Female	26.37±6.45	24.96±6.39		
KRQ-53	Male	148.92±28.12	146.15±34.53	2.72	0.10
	Female	155.69±21.87	158.63±15.39		
HPB	Male	79.62±19.36	79.08±23.36	2.03	0.16
	Female	83.94±13.85	87.20±12.99		

Data are presented as mean±standard deviation. *p<0.05. DHEA-S, dehydroepiandrosterone sulfate; PSQI, Pittsburgh Sleep Quality Index; ISI, Insomnia Severity Index; SSS, Stanford Sleepiness Scale; ESS, Epworth Sleepiness Scale; HADS, Hospital Anxiety Depression Scale; DASS-21, Depression, Anxiety, Stress Scales-21; PHQ-9, Patient Health Questionnaire-9; SCL-90-R, Symptom Checklist-90-R; PSS, Perceived Stress Scale; KRQ-53, Korean Resilience Quotient-53; HPB, Health-Promoting Behavior

epidemic, causing widespread psychological distress,[27] has made it imperative to adopt interventions that target stressors within the workplace. Our findings, based on objective measures, confirm that the forest healing program not only reduces stress but also significantly improves sleep quality,[17] offering a fresh perspective on addressing occupational stress across different job sectors. Mitigating the negative effects of stress can help employees avoid leaving their jobs and enhance their personal satisfaction.[28-30] This assertion has been confirmed through many different kinds of research projects.[31,32] Although IT specialists showed less variation in outcomes, suggesting a need for further exploration into work structure and autonomy, the overarching positive effects of forest treatment across occupational groups remained consistent.

However, this study has several limitations that should be considered when interpreting the results. Firstly, the small number of participants limited the study's representativeness and statistical significance. Secondly, Table 2 presents participants' weights and heights without providing a rationale for these measurements. Thirdly, the significant gender imbalance, with fewer males compared to females, may affect the interpretation of the results. These issues highlight the need for

clearer participant selection criteria and the provision of anthropometric data. Fourthly, the lack of observed physiological changes in the teacher group, likely due to their participation during school breaks and lower job stress, may limit the interpretation of the results. Further analysis is necessary to explore other factors such as age, years of teaching experience, gender, and lifestyle differences. Utilizing the teacher group as a control under normal work stress conditions in future studies would be beneficial. Fifthly, the study assessed the effects of the forest healing program through a before-and-after comparison without a placebo group, which limits the ability to account for natural changes over time. Lastly, the study did not evaluate the duration of the forest healing program's effects, so a follow-up is essential to assess its long-term impact and offer a more comprehensive discussion of the results. Future research is planned to address and improve upon these limitations.

In conclusion, this study revealed that the impact of forest therapy on reducing stress and increasing quality of sleep was consistent across various professions, including healthcare providers, IT specialists, and teachers. The differences in stress reduction might be attributed to individual physiological factors rather than to the specific occupations.

Availability of Data and Material

The datasets generated or analyzed during the study are not publicly available due to co-ownership with the Korea Forest Service's forestry researchers, requiring permission from the commissioning party for public release. However, they are available from the corresponding author on reasonable request.

Conflicts of Interest

The authors have no potential conflicts of interest to disclose.

Author Contributions

Data curation: Juhye Kweon, Hyeyun Kim, Yunsoo Kim. Formal analysis: Juhye Kweon, Heeyong Choi, Wooyoung Im, Hyeyun Kim. Funding acquisition: Juhye Kweon, Yunsoo Kim, Hyeyun Kim. Investigation: all authors. Methodology: Juhye Kweon, Yunsoo Kim, Hyeyun Kim. Project administration: Juhye Kweon, Yunsoo Kim, Hyeyun Kim. Resources: Juhye Kweon, Hyeyun Kim, Yunsoo Kim. Software: Hyeyun Kim, Heeyong Choi. Supervision: Juhye Kweon, Wooyoung Im, Hyeyun Kim. Validation: Juhye Kweon, Heeyong Choi, Wooyoung Im, Hyeyun Kim. Visualization: Juhye Kweon, Hyeyun Kim. Writing—original draft: Juhye Kweon, Heeyong Choi, Wooyoung Im, Hyeyun Kim. Writing—review & editing: Juhye Kweon, Heeyong Choi, Wooyoung Im, Hyeyun Kim

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